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Use of Calorimetry for End of Charge Determination

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## TESTING OF AEROSPACE BATTERIES @ BOEING

CHEMISTRY	SYMBOL	APPLICATIONS
Nickel Hydrogen	NiH <sub>2</sub>	Future Power Systems
Nickel Cadmium	NiCd	Small Power Subsystems
Nickel Metal Hydride	NiMH	SEDSAT Experiment
Fibrous Nickel Cadmium	F-NiCd	Starter Battery for Boeing 777
Lithium Thionyl Chloride	Li-SOCl <sub>2</sub>	NASA Space Qual
Lithium Bromine Complex	Li-BCX	NASA - EVA suit
Zinc Silver Oxide	Zn-AgO	Boeing - IUS

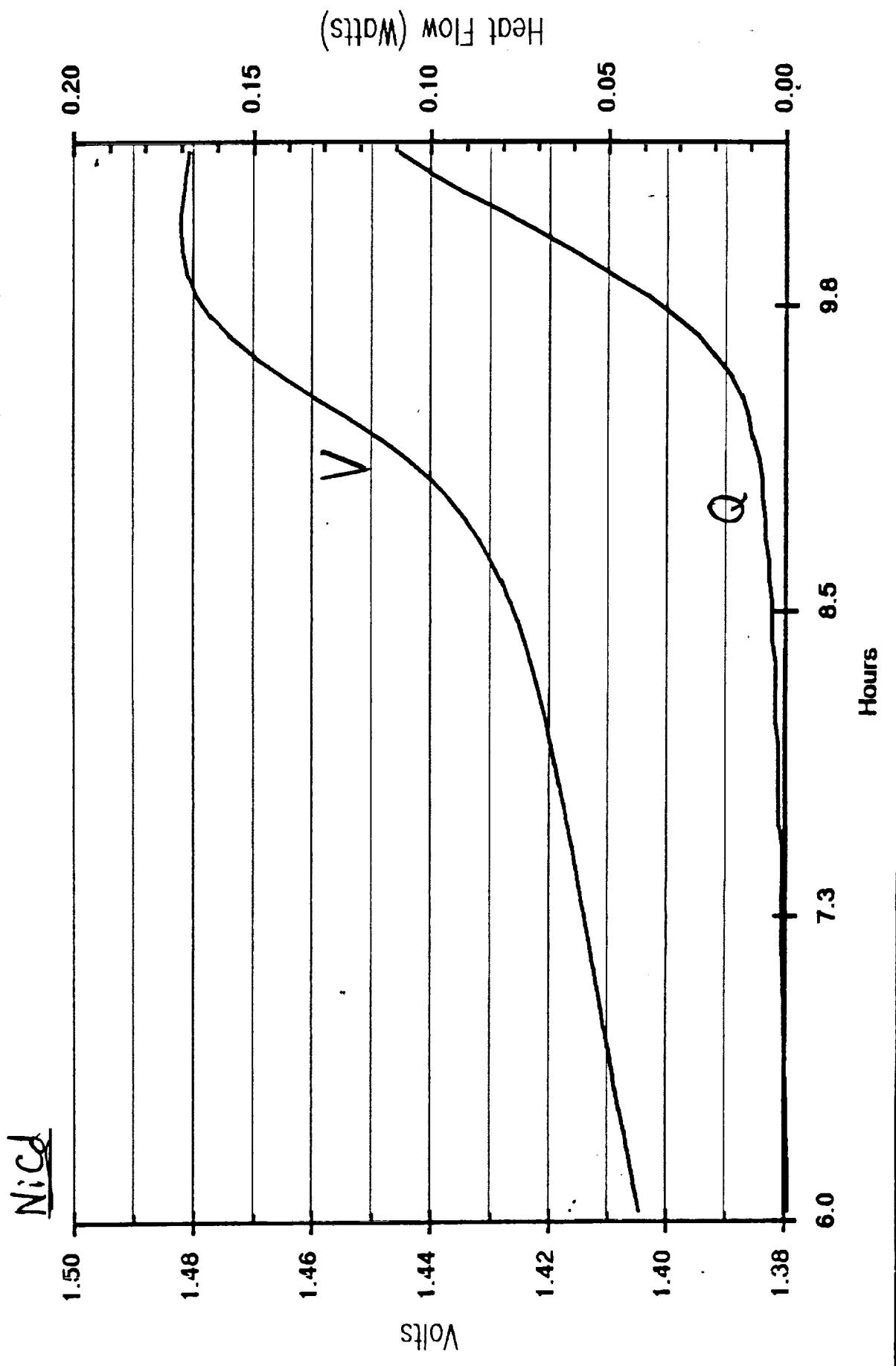
Application of Heat Flow Measurements on Batteries

- 1) ESTABLISH THERMAL NEUTRAL POTENTIAL  
PERMITS CALCULATION OF HEAT FLOW FROM VOLTAGE
- 2) IDENTIFY INEFFICIENT CHARGING  
$$\beta\text{-NiOOH} + \text{H}_2\text{O} + \text{e}^- \rightleftharpoons \beta\text{-Ni(OH)}_2 + \text{OH}^-$$
$$\text{H}_2 + 1/2\text{O}_2 \Rightarrow \text{H}_2\text{O} + \text{q}$$
- 3) UNDERSTAND SELF DISCHARGE MECHANISMS  
$$2 \text{ NiOOH} + \text{H}_2 \Rightarrow 2 \text{ Ni(OH)}_2 \quad \Delta H = 144.85 \text{ kJ/mole}$$
- 4) PROVIDE ACCURATE VOLTAGE/TEMP. DATA  
PARAMETRIC DATA NEEDED FOR VT CONTROL

INDICATORS of INEFFICIENT CHARGING

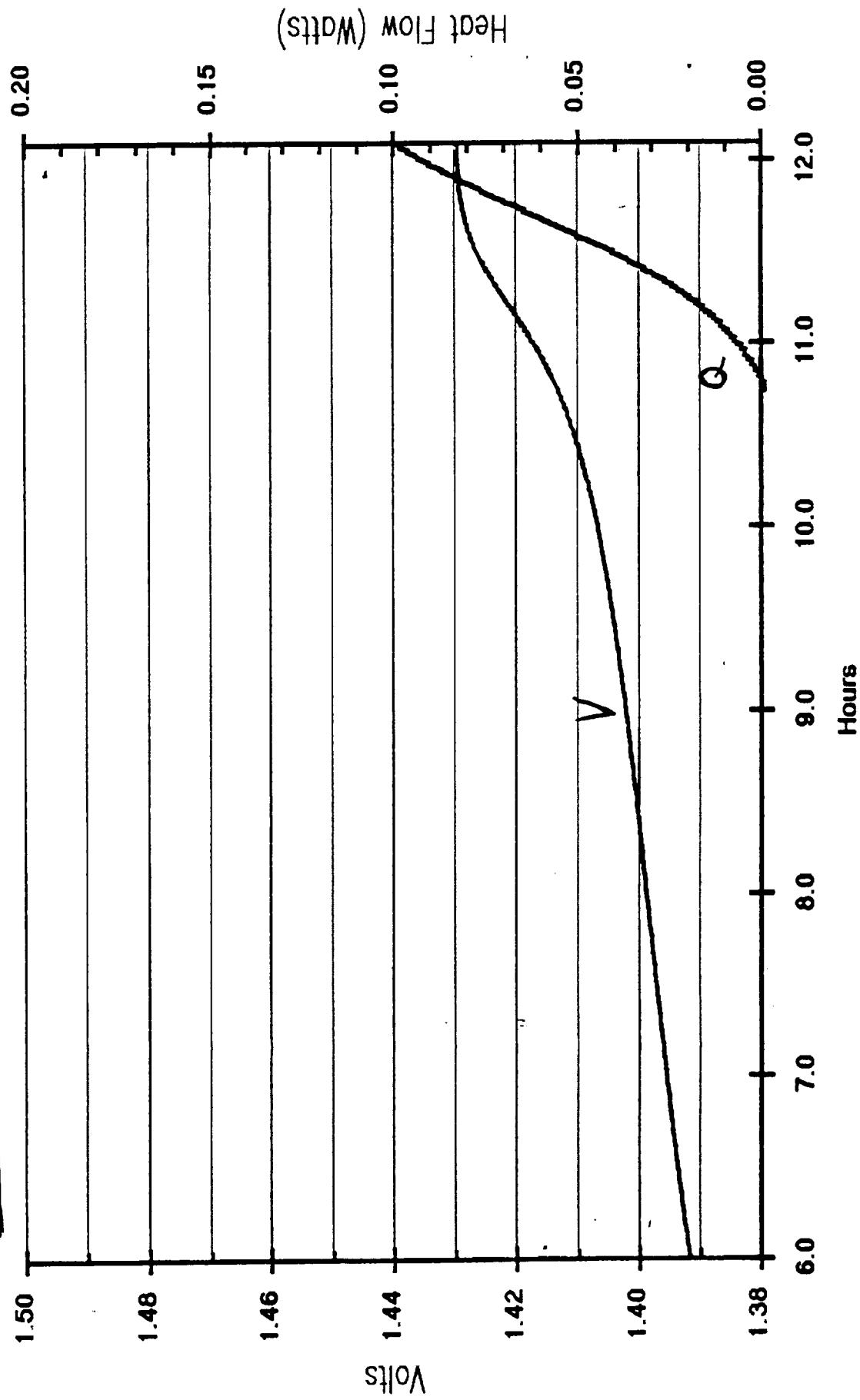
- 1) INCREASED HEAT FLOW FROM  $H_2 + O_2$  RECOMBINATION REACTION
- 2) VOLTAGE "ROLL OVER"
- 3) LOSS of LINEAR INCREASE IN PRESSURE on  $NiH_2$  CELLS

N1300 SCRT 1.3Ah Cell Charged at C/10 (0.134) @ 10C

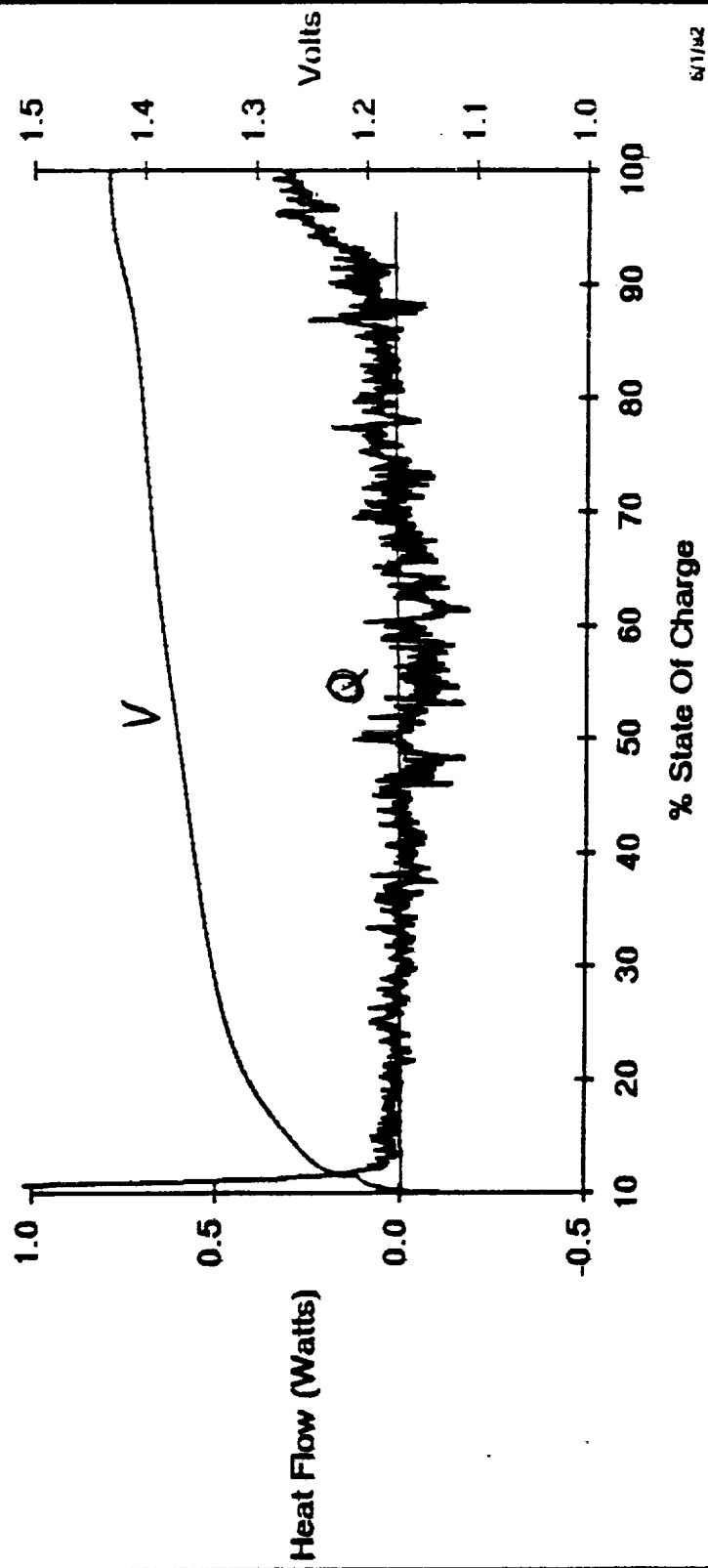


N1300 SCRT 1.3Ah Cell Charged at C/10 (0.13A) @ 30C

NiCd

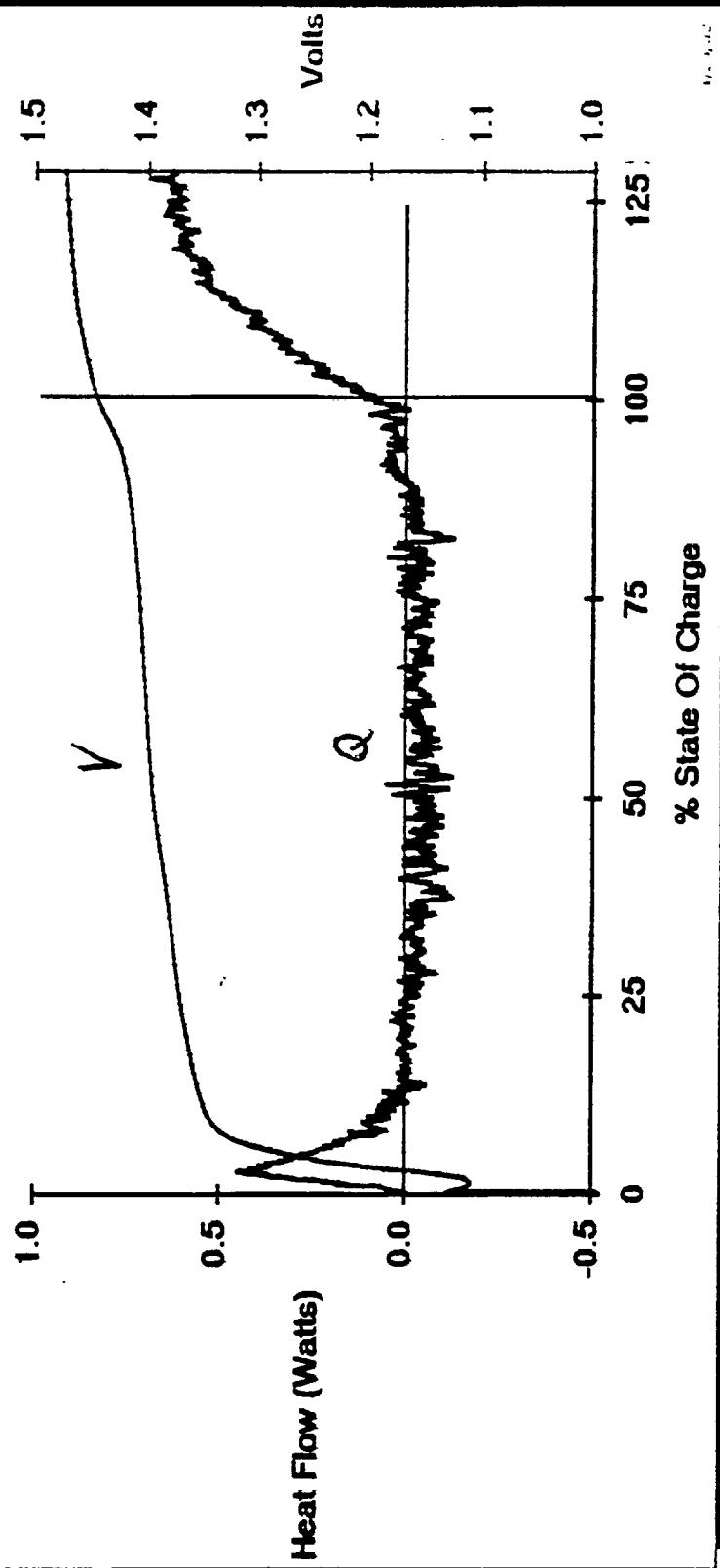


FNC Cell X7S, Charged at C/20 (0.35A), 20 Deg C.

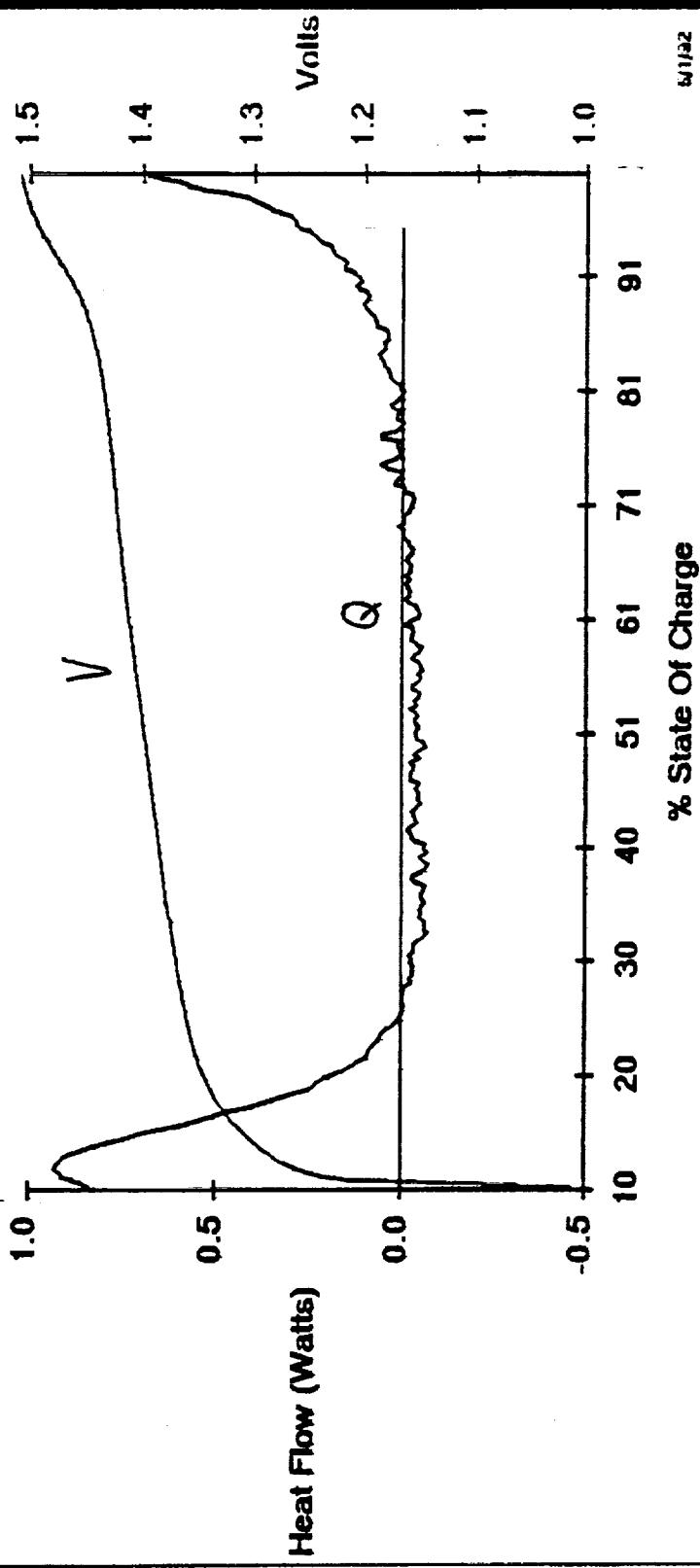


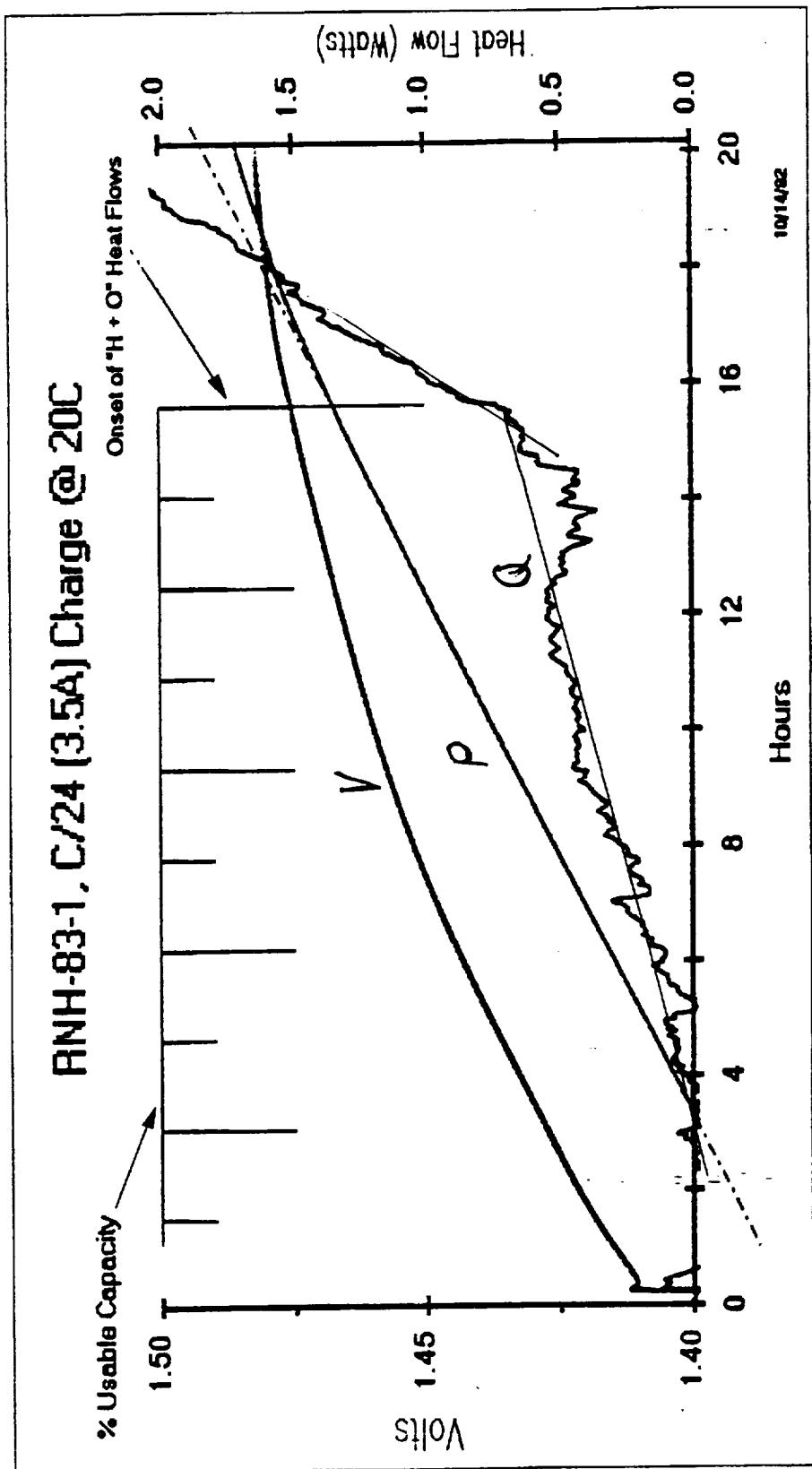
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FNC Cell X7S, Charged at C/10 (0.70A), 20 Deg C

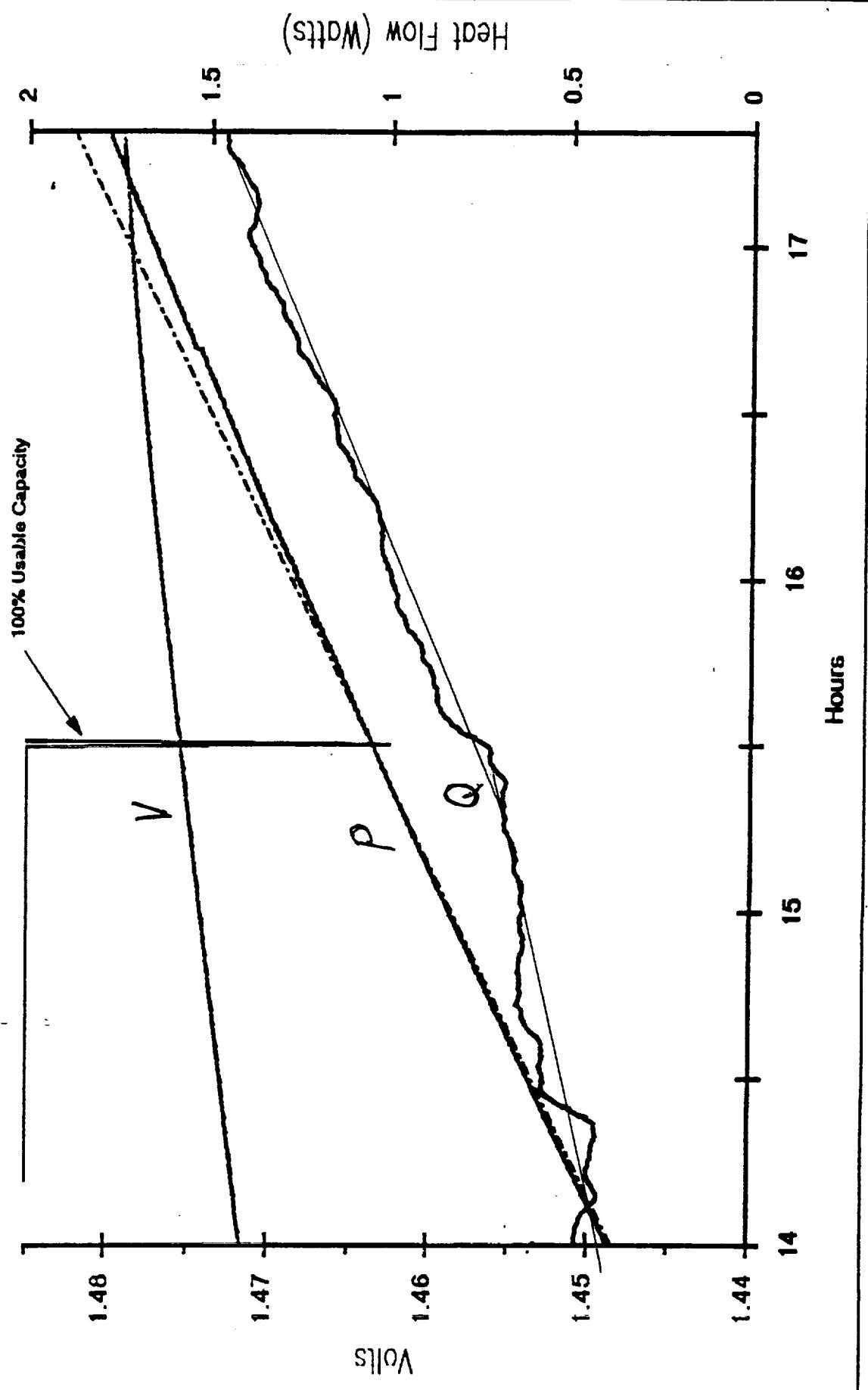


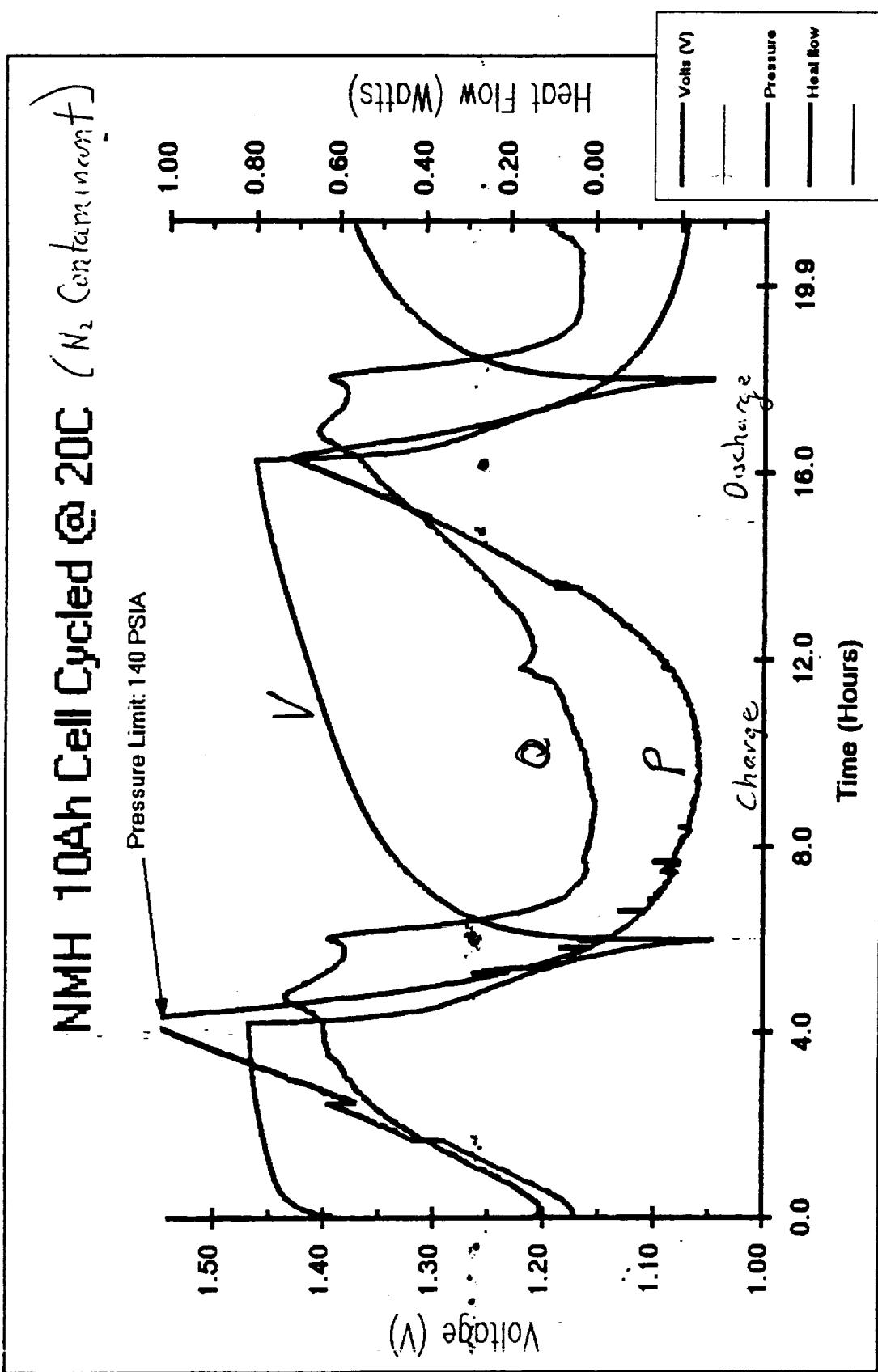
FNC Cell X75, Charged at C/2 (3.50A), 20 Deg C





## RNIH-83-1, C/24 (3.5A) Charge @ 20C [expanded view]





## NIMH Cell Gas Analysis - Preliminary Results Summary

Cell pressure recovers within minutes after sampling

Hydrogen and nitrogen predominant, lesser amounts water, oxygen, others

No evidence for the presence of methane

Significant percentage of oxygen present at 100% charge in one cycle

Oxygen consumed completely during discharge cycle

Explosive mixtures of hydrogen and oxygen are present at some times

Significant gas composition changes occur during storage in a discharged state

## SUMMARY

- 1) All Ni - Based Batteries Studied Indicated Increased Q @ End of Charge
- 2) NiH<sub>2</sub> Cells Showed Increase in Q related to Charge Inefficiency  
Q Increase & Deviation from Linear Increase in H<sub>2</sub> Pressure synonymous
- 3) Heat Flow (Q) from NiMH was Complicated by Presence of N<sub>2</sub> Contaminant



## Advanced Technologies Session

*Session Organizer: Eric Darcy  
NASA Johnson Space Center*

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